ARMY RESEARCH LABORATORY

Mechanisms of Military Coatings Degradation: Color and Gloss Performance Evaluation

by William S. Lum, Philip H. Patterson,
and John A. Escarsega

ARL-TR-2670 February 2002

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Mechanisms of Military Coatings Degradation: Color and Gloss Performance Evaluation

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Abstract

The Weapons and Materials Research Directorate of the U.S. Army Research Laboratory is leading a research study on military coatings degradation. The goal of this project is to provide detailed analysis of coating system failure mechanisms and, where possible, provide predictive capability to enable service life estimates for these systems. This interim report focuses on some of the initial durability data gathered on the coatings' exposures in Florida, Arizona, and in an accelerated ultraviolet light chamber. The changes occurring in the topcoats' camouflage properties (i.e., gloss, color, and infrared reflectance) due to these weathering effects are tabulated and discussed.

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1. Introduction

The U.S. Army Research Laboratory (ARL) Weapons and Materials Research Directorate (WMRD) is the lead activity responsible for managing a multi-year Strategic Environmental Research and Development Program (SERDP) that involves the study of military coatings degradation when exposed to various climatic environments. The ARL 2000 Annual Progress Report prepared for the SERDP Review Board provides the technical approach and experimental details of the investigation [1]. The goal of this joint service effort is to identify, model, and predict the degradation mechanisms that lead to coating performance failures. Although the research encompasses several components of degradation characterization, this report will focus only on the weathering effects of the topcoats' camouflage properties (i.e., gloss, color, and infrared [IR] reflectance). All of the durability data gathered to date on the coatings' exposures in Florida, Arizona, and in an accelerated ultraviolet (UV) light chamber will be presented.

2. Approach

2.1 Outdoor Weathering

Two separate geographical locations, Arizona and South Florida, were chosen for the natural weathering of the coated panels and free films. The outdoor exposures conformed to the requirements set forth in American Society for Testing and Materials (ASTM) standards G7 [2] and G147 [3]. Exposure testing was performed in Miami, FL (26° N) and New River, AZ (34° N) in accordance with governing standards at a tilt angle of 5° from the horizontal facing south for 7 and 13 weeks.

2.2 Accelerated Weathering

The coating specimens were weathered using accelerated weathering chambers,* conforming to the requirements set forth in ASTM G53 [4]. The chambers were equipped with UV-340 fluorescent UV lamps emitting a spectral irradiance of 0.77 W/m^2 measured at 340 nm. An automatic sensor controller kept this irradiance level stable throughout the testing. The controller was calibrated after every 400 hr of lamp operation. An exposure temperature of 60 °C was maintained inside the weathering chambers. The study was conducted

*Q-Panel Products, 26200 First St., Cleveland, OH 44145.

following an elapsed time schedule, with the samples exposed to continuous UV over the intervals of 3, 6, and 12 weeks.

2.3 Coating Materials

Table 1 describes the coating systems selected for exposure studies. Additionally, some general formulation and substrate information is provided.

Table 1. Coating systems selected for study.

A = (46168), Army Control System	
Top Coat	MIL-C-46168 [5] Type IV solvent-based polyurethane (siliceous extender) aliphatic isocyanates and polyester polyols
Primer	MIL-P-53022 [6] solvent-based epoxy
Surface Treatment	TT-C-490 [7] zinc phosphate on a steel substrate
B = Low volatile organic compound (VOC), Army Future System (SERDP PP-1056)	
Top Coat	Water dispersible chemical-agent-resistant coating (CARC) polyurethane (polymeric bead extender) aliphatic polyurethane dispersion and modified isocyanate
Primer	MIL-P-53030 [8] water-based epoxy
Surface Treatment	TT-C-490 [7] zinc phosphate on a steel substrate
C = (85285), Navy Control System	
Top Coat	MIL-C-85285 [9] solvent-based polyurethane
Primer	MIL-P-23377 [10] solvent-based epoxy
Surface Treatment	MIL-C-5541 [11] chemical conversion on an aluminum substrate
D = (Zero VOC TC), Navy Future System	
Top Coat	ZVOC TC [12] water-based polyurethane
Primer	MIL-P-85582 [13] water-based epoxy
Surface Treatment	MIL-C-5541 [11] chemical conversion on an aluminum substrate

3. Experimental

3.1 Sample Preparation

After each exposure interval, the samples were rinsed with deionized water and allowed to dry before color and gloss measurements were made. During the performance testing, all specimens were carefully handled to avoid marring, and the operators wore lint free gloves in order to keep coating surfaces clean.

3.2 Color and IR Reflectance

The color and IR reflectance measurements were performed using a Chroma Sensor 5 spectrophotometer* equipped with an 8-in (diameter) integrating sphere and a halogen-tungsten light source. The readings were taken in accordance with the requirements as set forth in the military coating specification, MIL-C-46168D [5]. The spectrophotometer was calibrated before each series of analyses, using the manufacturer's standard color tile (serial no. [S/N] 2621).

3.3 Gloss

Gloss measurements were made in accordance with ASTM D523 [14], using a GB 4606 Haze-Gloss Reflectometer.† The measurements were taken at two different angle geometries: 60° and 85°. The instrument's performance was verified before each series of analyses, using the manufacturer's reflectometer standard gloss tile (S/N 9017715).

4. Results and Conclusions

4.1 Outdoor Weathering

As one would expect, the degradation results for the samples weathered in Florida and Arizona do not show similar tendencies. Because the Arizona samples are exposed to very little humidity and moisture, degradation is primarily the result of UV exposure. However, the South Florida samples are not only exposed to UV radiation but also to significant amounts of humidity and moisture. These more extreme conditions often alter or accelerate the physical and chemical mechanisms that degrade organic coatings. The outdoor exposure data have been summarized in Table 2. Reported values are averages of readings taken from three separate samples.

The 7-week Arizona exposure had minimal effect upon the color change of the samples. All samples (A–D) showed no more than a 0.4 National Bureau of Standards (NBS) color unit difference when compared to their original or unexposed readings. The most pronounced change for the exposure period was the 60° and 85° gloss for sample C (a 0.4 loss at 60° and a 0.3 increase for 85°). For the 13-week Arizona exposures, sample C showed the least amount of color change with a delta value of only 0.3. Samples A, B, and D showed a greater color change, as indicated by the slightly higher values of 0.6, 0.6, and 0.7,

*Data Color International, 3537 Beam Rd., Charlotte, NC 28217.

†BYK Gardner, 9104 Guilford Rd., Columbia, MD 21046.

Table 2. Summary of exposure data: delta color (NBS units) and gloss values.

Aging Condition	Delta Color				Delta Gloss							
	A	B	C	D	A		B		C		D	
					60°	85°	60°	85°	60°	85°	60°	85°
Arizona 7 weeks	0.296	0.431	0.171	0.239	NC	0.2+	NC	0.2+	0.4–	0.3+	NC	NC
Arizona 13 weeks	0.588	0.617	0.315	0.719	0.1–	0.3+	NC	0.3+	0.7–	0.3+	0.3–	NC
Florida 7 weeks	0.099	0.701	0.463	1.13	ND	ND	ND	ND	ND	ND	ND	ND
Florida 13 weeks	0.488	0.876	0.409	1.54	NC	0.5+	NC	0.3+	0.36–	0.9+	0.2–	NC

Notes: NC = no change; ND = no data.

respectively. The 60° gloss further decreased for sample C to a delta of -0.7. A 0.3 unit loss in the 60° gloss is also noted for sample D.

The South Florida exposures appear to have had the most detrimental effect on the color stability of the water-dispersible coating systems (B and D). Conversely, even after 13 weeks of South Florida weathering, samples A and C showed little change in color. The one significant reversal is the gloss for sample C when compared to Arizona. The 60° value at 13 weeks is a -0.36 delta and a +0.9 delta for 85°, whereas the Arizona sample had the greatest impact on the 60° rather than the 85° values.

Finally, it should be noted that in all outdoor exposures, the coatings prepared as free films provided similar gloss and color differences with regard to the "coated systems" despite no pretreatment with an epoxy primer or conversion coating. This may assist in acquiring more information about the primer contribution to redirecting or reflecting photons back through the topcoat.

4.2 Accelerated Weathering

The results of the color and gloss analysis are provided in the appendix. In reviewing the tabulated results, it is apparent that of the four coating systems evaluated, system A, MIL-C-46168 [5] solvent-based polyurethane topcoat, shows the most pronounced signs of appearance degradation due to UV exposure. After just three weeks of exposure, some of the samples have already exceeded the 85° gloss requirement (>3.5 gloss units). Additional appearance degradation occurs after six weeks of exposure, as evidenced by the significant increase in the brightness (Y) values. The elevated Y values are responsible for the color error failures. Again, all of the samples tested during this exposure interval exceeded the allowable color change from the initial readings (>2.5 NBS units). Another notable performance failure involves the change in the IR ratio values. By not meeting this minimum requirement, the near-IR camouflage properties of these coatings have been compromised. This degradation trend

continues for the system A coatings during the 12-week exposure. In all instances, similar, if not greater, performance failures occur in the appearance and IR camouflage properties. These weathering characteristics may be related to the coatings' extender pigment content. A full disclosure of the pigment composition and volume concentration for all of the coating systems might provide the necessary insight to explain the inferior performance behavior of system A.

5. Future Work

Future work for this program involves the continued weathering of the coating materials. UV exposure intervals of 18 and 48 weeks are scheduled, as well as a continuance of the Arizona and South Florida natural weathering. The outdoor exposure intervals will be set at 25, 49, and 97 weeks. The test methodologies used for the current appearance measurements will not change. However, additional data, such as changes in chemical composition, will be incorporated and related to the physical property changes of the coatings. Also, spectral irradiance values will be reported with each of the exposure (natural and accelerated) intervals to establish and quantify energy dosage effects.

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14. American Society for Testing and Materials. "Tests for Chemical, Physical, and Optical Properties; Appearance." ASTM D523, *1999 Annual Book of ASTM Standards*, vol. 06.01, West Conshohocken, PA, 1999.

Appendix. Spreadsheets of Exposure Results

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The following tables provide the color and gloss data measured on coatings exposed in an ultraviolet (UV) accelerated weathering chamber over selected time intervals. Specification limits are also provided.

Table A-1. Three-week exposure results.

Army Testing and Evaluation (07 June 00)

Sample Identification	Tristimulus Values			Gloss		Color Error	Infrared Properties		
	X3/Xi	Y3/Yi	Z3/Zi	603/i	853/i	NBS3/i	IR Avg3/i	IR Red3/i	IR Ratio3/i
A-Q-0077-A-1	7.12/6.88	7.90/7.63	6.90/6.58	0.6/0.8	3.9/3.5	1.33/0.79	45.54/45.26	7.64/7.43	5.96/6.09
A-Q-0077-A-2	7.04/6.84	7.82/7.59	6.78/6.53	0.6/0.6	3.6/3.0	1.21/0.71	45.70/45.55	7.58/7.39	6.03/6.16
A-Q-0077-A-3	6.99/6.82	7.77/7.58	6.70/6.51	0.6/0.6	4.1/3.0	0.98/0.68	45.77/45.73	7.53/7.37	6.08/6.20
B-Q-0075-A-1	6.96/6.87	7.84/7.71	6.63/6.59	0.8/0.8	2.3/2.1	1.41/1.18	49.42/49.33	7.41/7.33	6.67/6.73
B-Q-0075-A-2	6.92/6.74	7.81/7.58	6.60/6.43	0.7/0.7	2.1/1.8	1.51/1.10	49.49/49.35	7.37/7.21	6.71/6.85
B-Q-0075-A-3	6.85/6.61	7.73/7.45	6.50/6.27	0.7/0.6	1.9/1.6	1.37/1.10	49.21/49.01	7.30/7.09	6.50/6.92
C-Q-0069-A-1	33.94/34.06	35.10/35.23	45.60/45.53	1.6/2.6	3.9/3.6	0.33/--			
C-Q-0069-A-2	33.87/34.02	35.03/35.19	45.51/45.48	1.8/2.5	4.4/3.4	0.34/--			
C-Q-0069-A-3	34.00/34.09	35.17/35.25	45.68/45.57	2.0/2.4	5.6/3.4	0.33/--			
D-Q-0074-A-1	35.93/36.20	37.17/37.40	47.87/48.56	2.0/2.2	4.6/4.5	0.49/--			
D-Q-0074-A-2	36.22/36.50	37.46/37.50	48.28/48.92	2.0/2.2	4.8/4.6	0.45/--			
D-Q-0074-A-3	36.26/36.53	37.49/37.73	48.35/48.99	2.0/2.2	4.9/4.8	0.43/--			
A-Q-0077-N-1	7.13/6.88	7.92/7.64	6.86/6.59	0.6/0.6	3.5/2.9	1.24/0.81	45.56/45.41	7.68/7.44	5.93/6.10
A-Q-0077-N-2	7.16/6.83	7.96/7.58	6.88/6.51	0.6/0.6	3.2/3.0	1.27/0.67	45.68/45.31	7.72/7.39	5.91/6.13
B-Q-0075-N-1	7.05/6.74	7.94/7.57	6.78/6.46	0.7/0.7	2.0/1.6	1.62/1.09	49.09/48.76	7.50/7.21	6.55/6.76
B-Q-0075-N-2	7.03/6.69	7.91/7.51	6.76/6.40	0.7/0.7	1.9/1.4	1.54/0.99	49.29/48.98	7.47/7.16	6.59/6.84
C-Q-0069-N-1	33.77/33.80	34.93/34.96	45.35/45.21	1.6/2.1	3.9/3.1	0.24/--			
C-Q-0069-N-2	33.96/33.96	35.12/35.12	45.64/45.41	1.8/2.3	4.4/3.6	0.31/--			
D-Q-0074-N-1	36.44/36.68	37.68/37.88	48.54/49.17	2.0/2.0	4.8/4.4	0.45/--			
D-Q-0074-N-2	36.30/36.54	37.54/37.74	48.37/49.0	1.8/2.1	4.6/4.5	0.45/--			
A-Q-0077-M-1	6.96/6.78	7.74/7.53	6.66/6.46	0.6/0.7	2.8/2.8	0.91/0.59	45.76/45.55	7.51/7.34	6.09/6.21
B-Q-0075-M-1	6.96/6.70	7.84/7.53	6.67/6.40	0.7/0.7	1.9/1.5	1.48/1.05	49.08/48.80	7.42/7.18	6.61/6.80
C-Q-0069-M-1	33.73/33.80	34.88/34.96	45.34/45.20	1.6/2.2	4.0/3.3	0.32/--			
D-Q-0074-M-1	36.07/36.11	37.29/37.30	48.07/48.42	1.9/2.0	4.4/4.2	0.39/--			
A-Q-0076-M-6TOP	7.02/6.86	7.817.62	6.65/6.51	0.6/0.6	3.4/2.3	0.89/0.64	46.04/45.51	7.60/7.45	6.06/6.11
A-Q-0076-M-6BOT	7.01/6.62	7.79/7.36	6.63/6.25	0.7/0.6	3.8/2.3	0.85/0.24	42.78/44.23	7.59/7.20	5.64/6.14
B-Q-0076-M-6TOP	6.56/6.25	7.37/7.01	6.09/5.78	0.7/0.6	1.9/2.3	0.74/0.79	46.86/45.45	7.08/6.80	6.62/6.83
B-Q-0076-M-6BOT	6.63/6.62	7.46/7.03	6.21/5.83	0.7/0.6	2.3/2.2	0.89/0.82	46.15/45.51	7.12/6.79	6.48/6.71
C-Q-0076-M-6TOP	32.90/32.86	34.04/34.01	44.02/43.74	1.3/0.6	2.8/2.3	0.31/--			
C-Q-0076-M-6BOT	34.03/33.78	35.20/34.95	45.65/45.02	1.4/0.6	3.1/2.2	0.46/--			
D-Q-0076-M-6TOP	35.38/35.34	36.59/36.50	47.17/47.40	1.6/0.6	2.2/2.3	0.40/--			
D-Q-0076-M-6BOT	35.50/35.55	36.69/36.72	47.28/47.61	1.8/0.6	3.4/2.4	0.34/--			

Specification Requirements for Green 383 Camouflage Topcoats:*

*** Samples Beginning with the Letters A or B**

60 Gloss: 1.0 (Max) **85 Gloss: 3.5 (Max)**
Gloss- Allowable Change: 0.5 Unit Increase From Initial Reading

Color Error- Allowable Change: 2.5 NBS Units From Initial Color Reading and Within 2.5 NBS Units From Center of the Color Ellipse

Visual(Y) Range: 6.30 - 8.30

IR AVG: 60.0 (Maximum)

IR Ratio: 5.2 (Minimum)

Table A-2. Six-week exposure results.

Army Testing and Evaluation (30 June 00)

Sample Identification	Tristimulus Values			Gloss		Color Error	Infrared Properties		
	X6/Xi	Y6/Yi	Z6/Zi	606/i	856/i	NBS6/i	IR Avg6/i	IR Red6/i	IR Ratio6/i
A-Q-0077-A-4	8.75/6.88	9.61/7.65	8.92/6.58	0.6/0.6	3.2/3.1	4.44/0.79	46.43/45.73	9.22/7.44	5.04/6.15
A-Q-0077-A-5	8.79/6.85	9.66/7.62	8.92/6.51	0.6/0.6	2.6/2.8	4.43/0.65	46.71/45.84	9.29/7.42	5.03/6.18
A-Q-0077-A-6	8.43/6.85	9.27/7.61	8.44/6.52	0.6/0.6	2.4/2.5	3.72/0.67	46.29/45.64	8.94/7.41	5.51/6.16
B-Q-0075-A-4	6.90/6.67	7.79/7.51	6.58/6.34	0.7/0.7	2.0/1.8	1.51/1.09	48.74/48.60	7.34/7.14	6.64/6.81
B-Q-0075-A-5	6.91/6.69	7.80/7.52	6.60/6.36	0.7/0.7	2.0/1.7	1.52/0.98	49.12/49.02	7.35/7.16	6.68/6.85
B-Q-0075-A-6	6.96/6.71	7.85/7.55	6.65/6.39	0.7/0.7	2.0/1.8	1.53/1.09	48.88/48.79	7.40/7.18	6.61/6.79
C-Q-0069-A-4	34.20/34.12	35.36/35.28	45.94/45.64	1.5/2.4	3.4/3.5	0.26/--			
C-Q-0069-A-5	34.21/34.15	35.37/35.32	45.93/45.65	1.5/2.5	3.5/3.6	0.27/--			
C-Q-0069-A-6	34.01/34.03	35.17/35.20	45.70/45.54	1.5/2.3	3.4/3.4	0.25/--			
D-Q-0074-A-4	36.18/36.72	37.42/37.93	48.28/49.25	1.8/2.2	4.8/4.8	0.58/--			
D-Q-0074-A-5	36.19/36.65	37.42/37.85	48.28/49.16	1.8/2.2	4.8/4.7	0.53/--			
D-Q-0074-A-6	36.07/36.59	37.30/37.79	48.12/49.08	1.7/2.1	4.5/4.5	0.58/--			
A-Q-0077-N-3	8.47/6.82	9.31/7.58	8.49/6.5	0.6/0.6	2.7/2.3	3.79/0.65	46.18/45.36	8.98/7.38	5.14/6.14
A-Q-0077-N-4	8.69/6.83	9.54/7.59	8.75/6.51	0.6/0.6	2.6/2.8	4.18/0.66	46.26/45.38	9.21/7.39	5.03/6.14
B-Q-0075-N-3	6.98/6.77	7.87/7.61	6.68/6.47	0.8/0.7	2.2/1.9	1.55/1.12	48.65/48.15	7.42/7.24	6.56/6.70
B-Q-0075-N-4	7.01/6.73	7.88/7.55	6.74/6.45	0.7/0.7	1.8/1.5	1.46/1.01	49.28/49.22	7.44/7.20	6.62/6.84
C-Q-0069-N-3	33.96/33.97	35.11/35.13	45.63/45.43	1.5/2.2	3.7/3.5	0.28/--			
C-Q-0069-N-4	34.01/33.97	35.16/35.13	45.67/45.42	1.5/2.2	3.5/3.6	0.27/--			
D-Q-0074-N-3	35.77/36.25	37.00/37.44	47.73/48.60	1.7/2.0	4.4/4.4	0.53/--			
D-Q-0074-N-4	35.76/36.23	36.99/37.42	47.68/48.58	1.7/2.0	4.4/4.4	0.55/--			
A-Q-0077-M-2	8.22/6.79	9.06/7.54	8.24/6.48	0.6/0.7	2.9/3.0	3.42/0.64	46.31/45.53	8.72/7.34	5.31/6.20
B-Q-0075-M-2	6.96/6.67	7.85/7.50	6.66/6.36	0.7/0.7	1.8/1.5	1.54/1.03	49.05/48.81	7.41/7.15	6.62/6.83
C-Q-0069-M-2	34.24/33.88	35.40/35.05	45.95/45.30	1.4/2.2	3.2/3.2	0.40/--			
D-Q-0074-M-2	36.03/36.41	37.27/37.60	48.07/48.81	1.7/2.0	4.5/4.4	0.47/--			
A-Q-0076-M-7TOP	8.65/6.87	9.50/7.62	8.60/6.50	0.5/0.6	0.9/2.4	3.97/0.63	46.57/45.44	9.23/7.47	5.05/6.08
A-Q-0076-M-7BOT	8.12/6.79	8.94/7.54	7.97/6.44	0.5/0.6	1.2/2.3	3.01/0.53	45.69/44.69	8.69/7.38	5.26/6.06
B-Q-0076-M-7TOP	6.58/6.26	7.41/7.02	6.11/5.78	0.4/0.6	0.5/2.2	0.92/0.78	47.07/46.84	7.12/6.80	6.61/6.88
B-Q-0076-M-7BOT	6.71/6.37	7.55/7.14	6.30/5.95	0.4/0.6	1.0/2.2	0.96/0.61	45/96/45.47	7.21/6.90	6.38/6.59
C-Q-0076-M-7TOP	32.99/32.72	34.12/33.86	44.24/43.68	1.2/0.6	0.9/2.4	0.37/--			
C-Q-0076-M-7BOT	35.35/33.45	36.53/34.61	47.41/44.59	1.2/0.6	1.8/2.4	1.85/--			
D-Q-0076-M-7TOP	35.34/35.44	36.55/36.61	47.17/47.55	1.4/0.6	1.7/2.3	0.35/--			
D-Q-0076-M-7BOT	35.13/35.37	36.33/36.53	46.90/47.38	1.6/0.6	4.3/2.6	0.32/--			

Specification Requirements for Green 383 Camouflage Topcoat:

* **Samples Beginning with the Letters A or B**

60 Gloss: 1.0 (Max) **85 Gloss:** 3.5 (Max)
Gloss- Allowable Change: 0.5 Unit Increase From Initial Reading

Color Error- Allowable Change: 2.5 NBS Units From Initial Color Reading and Within 2.5 NBS Units From Center of the Color Ellipse

Visual(Y) Range: 6.30 - 8.30

IR AVG: 60.0 (Maximum)

IR Ratio: 5.2 (Minimum)

Table A-3. 12-week exposure results.

Army Testing and Evaluation (16 Aug 00)

Sample Identification	Tristimulus Values			Gloss		Color Error	Infrared Properties		
	X12/Xi	Y12/Yi	Z12/Zi	6012/i	8512/i	NBS12/i	IR Avg12/i	IR Red12/i	IR Ratio12/i
A-Q-0077-A-7	10.02/6.82	10.94/7.57	9.69/6.51	0.6/0.6	2.6/2.9	5.96/0.68	47.75/45.47	10.82/7.37	4.41/6.17
A-Q-0077-A-8	9.93/6.85	10.84/7.61	9.76/6.55	0.6/0.6	2.5/2.9	5.90/0.74	47.46/45.46	10.65/7.41	4.45/6.14
A-Q-0077-A-9	9.96/6.87	10.87/7.64	9.77/6.55	0.6/0.6	2.6/3.0	5.94/0.73	47.59/45.65	10.70/7.44	4.45/6.14
B-Q-0075-A-7	7.05/6.76	7.95/7.60	6.75/6.45	0.8/0.7	2.1/1.8	1.64/1.10	49.19/48.96	7.50/7.22	6.56/6.78
B-Q-0075-A-8	7.05/6.74	7.95/7.57	6.75/6.42	0.7/0.7	2.0/1.7	1.64/0.99	48.32/49.00	7.48/7.20	6.59/6.81
B-Q-0075-A-9	7.03/6.75	7.94/7.59	6.72/6.44	0.7/0.7	2.0/1.8	1.70/1.10	49.24/48.89	7.48/7.22	6.59/6.77
C-Q-0069-A-7	35.00/33.85	36.17/35.01	46.74/45.28	1.4/2.3	3.3/3.4	1.10/--			
C-Q-0069-A-8	34.42/34.08	35.59/35.25	46.00/45.57	1.4/2.3	3.4/3.5	0.32/--			
C-Q-0069-A-9	34.39/34.13	35.55/35.30	45.95/45.64	1.7/2.4	3.8/3.7	0.25/--			
D-Q-0074-A-7	36.25/36.85	37.49/38.06	48.26/49.42	1.6/2.1	4.7/4.7	0.70/--			
D-Q-0074-A-8	36.06/36.65	37.30/37.85	48.03/49.16	1.6/2.1	4.6/4.8	0.69/--			
D-Q-0074-A-9	36.15/36.74	37.39/37.95	48.14/49.27	1.6/2.1	4.5/4.6	0.68/--			
A-Q-0077-N-5	6.70/6.82	11.30/7.58	10.38/6.49	0.6/0.6	2.4/2.8	6.70/0.62	47.54/45.44	11.05/7.38	4.30/6.16
A-Q-0077-N-6	10.53/6.82	11.47/7.58	10.54/6.50	0.6/0.6	2.7/2.8	6.95/0.65	47.66/45.41	11.23/7.38	4.24/6.15
B-Q-0075-N-5	7.05/6.71	7.95/7.54	6.77/6.43	0.7/0.7	1.9/1.6	1.68/1.09	49.50/49.29	7.49/7.18	6.61/6.86
B-Q-0075-N-6	7.07/6.75	7.96/7.57	6.80/6.48	0.7/0.7	1.9/1.5	1.63/1.04	49.52/49.21	7.50/7.22	6.60/6.82
C-Q-0069-N-5	34.50/33.88	35.67/35.04	46.14/45.31	1.4/2.2	3.5/3.5	0.59/--			
C-Q-0069-N-6	34.40/34.05	35.57/35.21	45.99/45.48	1.4/2.2	3.4/3.3	0.34/--			
D-Q-0074-N-5	36.02/36.66	37.25/37.86	47.96/49.16	1.6/2.0	4.4/4.4	0.72/--			
D-Q-0074-N-6	36.10/36.72	37.34/37.92	48.07/49.23	1.6/2.0	4.3/4.4	0.70/--			
A-Q-0077-M-3	10.28/6.8	11.23/7.56	10.01/6.49	0.6/0.6	1.7/2.5	6.40/0.65	47.98/45.40	11.08/7.36	4.33/6.17
B-Q-0075-M-3	7.02/6.70	7.92/7.53	6.54/6.38	0.6/0.7	1.8/1.7	1.62/1.00	48.80/48.38	7.46/7.18	6.54/6.74
C-Q-0069-M-3	35.44/34.00	36.61/35.16	47.22/45.46	1.4/2.4	3.4/3.6	1.38/--			
D-Q-0074-M-3	35.79/36.35	37.02/37.54	47.67/48.74	1.6/2.0	4.4/4.4	0.65/--			
A-Q-0076-M-8TOP	11.55/6.83	12.54/7.59	11.42/6.45	0.6/0.6	1.0/2.4	8.43/0.53	49.09/45.50	12.41/7.43	3.95/6.12
A-Q-0076-M-8BOT	11.30/6.74	12.27/7.48	11.22/6.37	0.6/0.6	1.0/2.4	8.07/0.42	48.08/44.70	12.13/7.33	3.96/6.10
B-Q-0076-M-8TOP	6.74/6.35	7.58/7.12	6.25/5.87	0.5/0.6	0.7/2.3	0.94/0.68	47.67/46.95	7.25/6.91	6.58/6.79
B-Q-0076-M-8BOT	6.67/6.22	7.52/6.98	6.23/5.78	0.6/0.6	0.8/2.4	1.06/0.83	46.31/45.46	7.15/6.74	6.47/6.74
C-Q-0076-M-8TOP	34.55/32.78	35.71/33.93	45.98/43.69	1.1/0.6	1.2/2.2	1.70/--			
C-Q-0076-M-8BOT	40.40/33.56	41.68/34.72	53.57/44.73	1.3/0.6	1.2/2.3	6.37/--			
D-Q-0076-M-8TOP	35.47/35.64	36.69/36.81	47.28/47.79	1.4/0.6	2.9/2.4	0.42/--			
D-Q-0076-M-8BOT	35.50/35.49	36.72/36.66	47.27/47.58	1.4/0.6	2.6/2.5	0.44/--			

Specification Requirements for Green 383 Camouflage Topcoats:*

* **Samples Beginning with the Letters A or B**

60 Gloss: 1.0 (Max) **85 Gloss:** 3.5 (Max)
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Visual(Y) Range: 6.30 - 8.30

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The Weapons and Materials Research Directorate of the U.S. Army Research Laboratory is leading a research study on military coatings degradation. The goal of this project is to provide detailed analysis of coating system failure mechanisms and where possible provide predictive capability to enable service life estimates for these systems. This interim report focuses on some of the initial durability data gathered on the coatings' exposures in Florida, Arizona, and in an accelerated ultraviolet light chamber. The changes occurring in the topcoats' camouflage properties (i.e., gloss, color, and infrared reflectance) due to these weathering effects are tabulated and discussed.

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